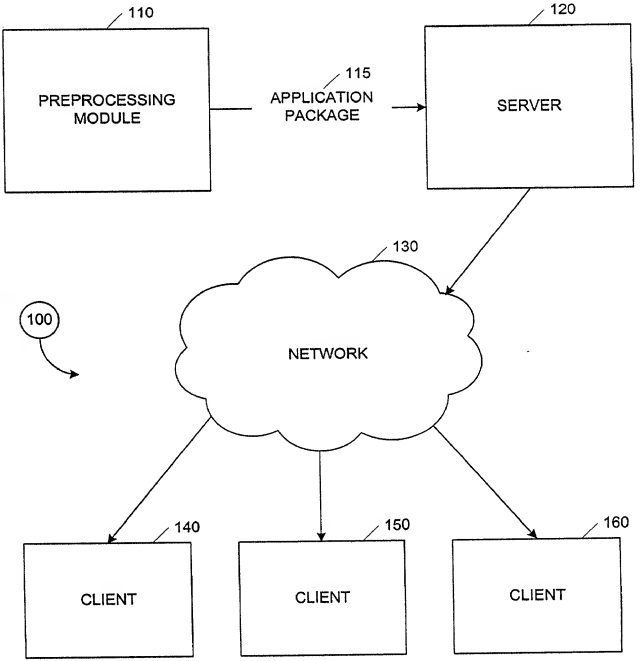
110
PREPROCESSING MODULE
115
APPLICATION PACKAGE
120
SERVER
130
NETWORK
100
140
CLIENT
150
CLIENT
160
CLIENT

FIG. 1

10020607.081202

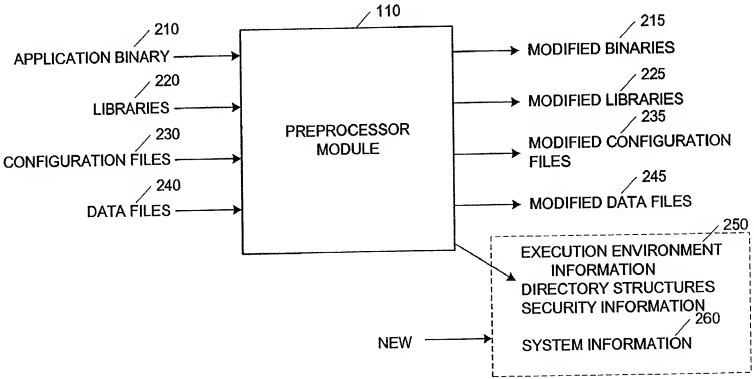

FIG. 2

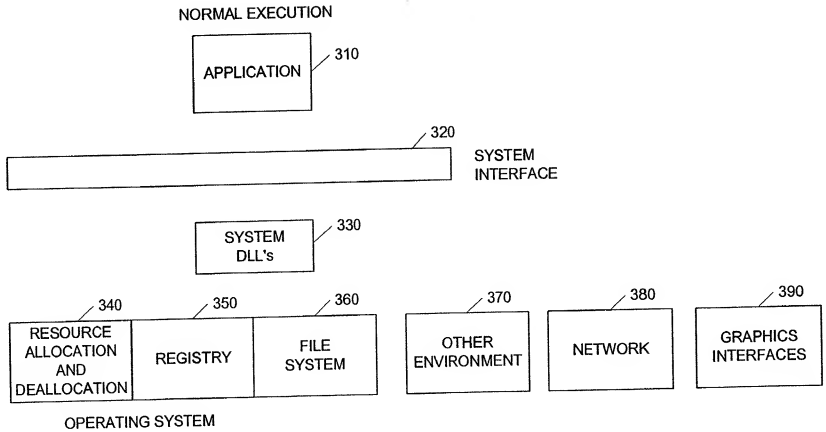
NORMAL EXECUTION
APPLICATION
310
320
SYSTEM INTERFACE
SYSTEM DLL's
330
340
RESOURCE ALLOCATION AND DEALLOCATION
350
REGISTRY
360
FILE SYSTEM
OPERATING SYSTEM
370
OTHER ENVIRONMENT
380
NETWORK
390
GRAPHICS INTERFACES

FIG. 3

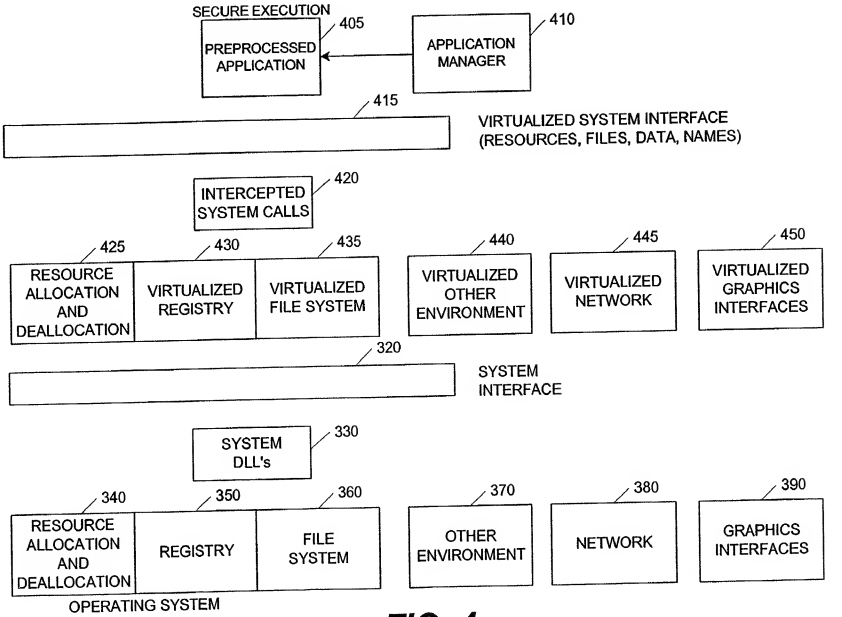
SECURE EXECUTION
405
PREPROCESSED APPLICATION
410
APPLICATION MANAGER
415
VIRTUALIZED SYSTEM INTERFACE (RESOURCES, FILES, DATA, NAMES)
420
INTERCEPTED SYSTEM CALLS
425
RESOURCE ALLOCATION AND DEALLOCATION
430
VIRTUALIZED REGISTRY
435
VIRTUALIZED FILE SYSTEM
440
VIRTUALIZED OTHER ENVIRONMENT
445
VIRTUALIZED NETWORK
450
VIRTUALIZED GRAPHICS INTERFACES
320
SYSTEM INTERFACE
330
SYSTEM DLL's
340
RESOURCE ALLOCATION AND DEALLOCATION
350
REGISTRY
360
FILE SYSTEM
370
OTHER ENVIRONMENT
380
NETWORK
390
GRAPHICS INTERFACES
OPERATING SYSTEM

FIG. 4

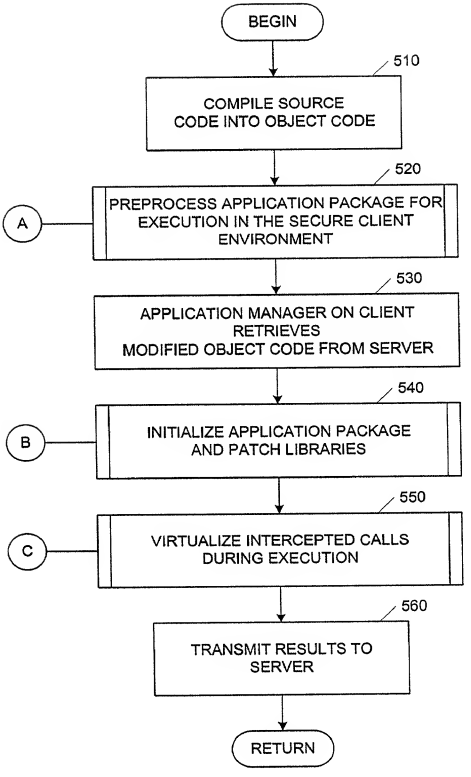
BEGIN
510
COMPILE SOURCE CODE INTO OBJECT CODE
520
A
PREPROCESS APPLICATION PACKAGE FOR EXECUTION IN THE SECURE CLIENT ENVIRONMENT
530
APPLICATION MANAGER ON CLIENT RETRIEVES MODIFIED OBJECT CODE FROM SERVER
540
B
INITIALIZE APPLICATION PACKAGE AND PATCH LIBRARIES
550
C
VIRTUALIZE INTERCEPTED CALLS DURING EXECUTION
560
TRANSMIT RESULTS TO SERVER
RETURN

FIG. 5

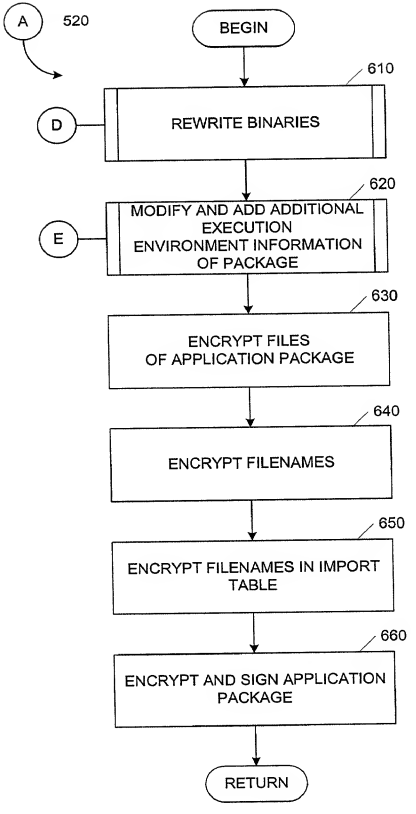
A
520
BEGIN
610
D
REWRITE BINARIES
620
E
MODIFY AND ADD ADDITIONAL EXECUTION ENVIRONMENT INFORMATION OF PACKAGE
630
ENCRYPT FILES OF APPLICATION PACKAGE
640
ENCRYPT FILENAMES
650
ENCRYPT FILENAMES IN IMPORT TABLE
660
ENCRYPT AND SIGN APPLICATION PACKAGE
RETURN

FIG. 6

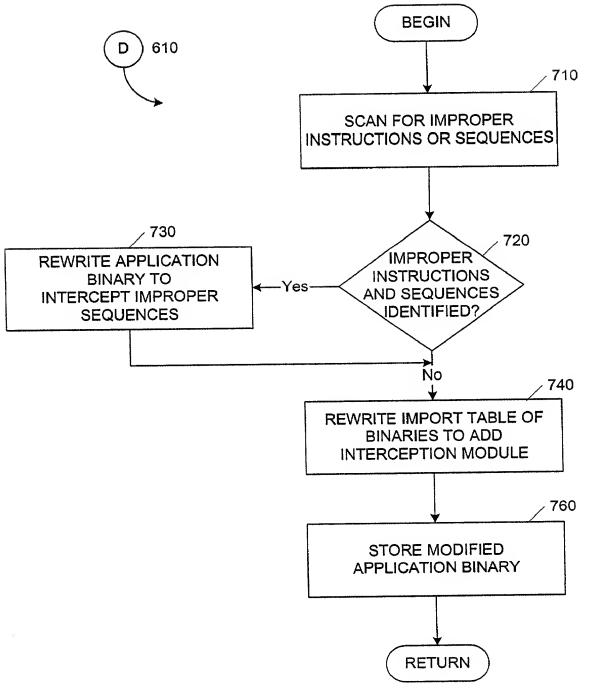
BEGIN
D
610
710
SCAN FOR IMPROPER INSTRUCTIONS OR SEQUENCES
720
IMPROPER INSTRUCTIONS AND SEQUENCES IDENTIFIED?
Yes
730
REWRITE APPLICATION BINARY TO INTERCEPT IMPROPER SEQUENCES
No
740
REWRITE IMPORT TABLE OF BINARIES TO ADD INTERCEPTION MODULE
760
STORE MODIFIED APPLICATION BINARY
RETURN

FIG. 7

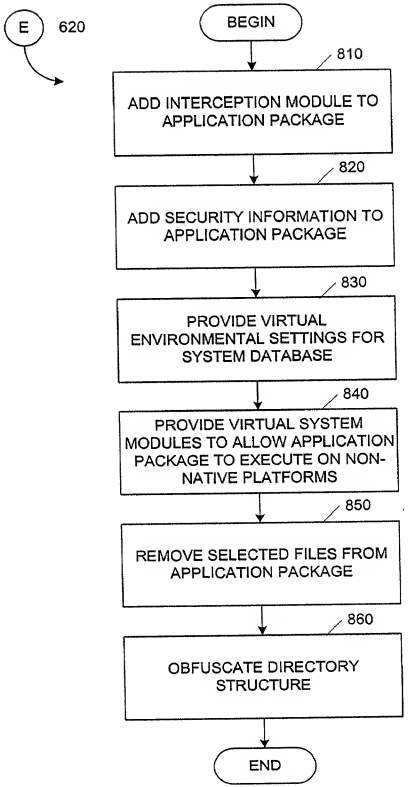
E
620
BEGIN
810
ADD INTERCEPTION MODULE TO APPLICATION PACKAGE
820
ADD SECURITY INFORMATION TO APPLICATION PACKAGE
830
PROVIDE VIRTUAL ENVIRONMENTAL SETTINGS FOR SYSTEM DATABASE
840
PROVIDE VIRTUAL SYSTEM MODULES TO ALLOW APPLICATION PACKAGE TO EXECUTE ON NON-NATIVE PLATFORMS
850
REMOVE SELECTED FILES FROM APPLICATION PACKAGE
860
OBFUSCATE DIRECTORY STRUCTURE
END

FIG. 8

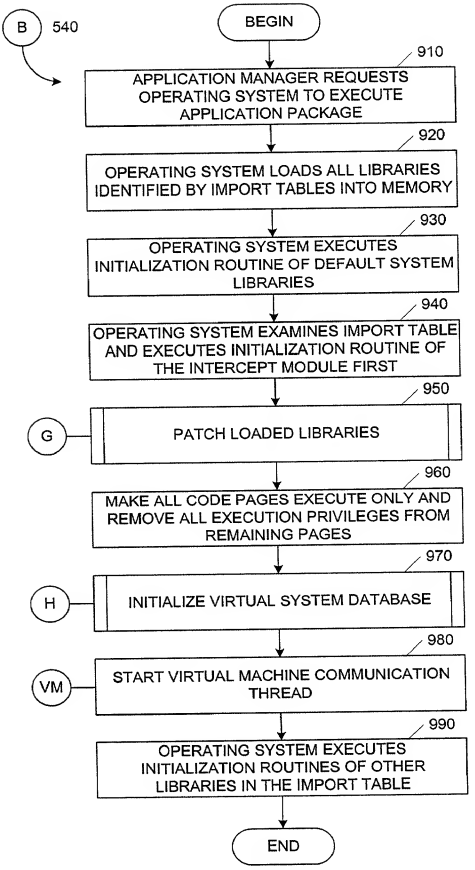
B
540
BEGIN
910
APPLICATION MANAGER REQUESTS OPERATING SYSTEM TO EXECUTE APPLICATION PACKAGE
920
OPERATING SYSTEM LOADS ALL LIBRARIES IDENTIFIED BY IMPORT TABLES INTO MEMORY
930
OPERATING SYSTEM EXECUTES INITIALIZATION ROUTINE OF DEFAULT SYSTEM LIBRARIES
940
OPERATING SYSTEM EXAMINES IMPORT TABLE AND EXECUTES INITIALIZATION ROUTINE OF THE INTERCEPT MODULE FIRST
950
G
PATCH LOADED LIBRARIES
960
MAKE ALL CODE PAGES EXECUTE ONLY AND REMOVE ALL EXECUTION PRIVILEGES FROM REMAINING PAGES
970
H
INITIALIZE VIRTUAL SYSTEM DATABASE
980
VM
START VIRTUAL MACHINE COMMUNICATION THREAD
990
OPERATING SYSTEM EXECUTES INITIALIZATION ROUTINES OF OTHER LIBRARIES IN THE IMPORT TABLE
END

FIG. 9

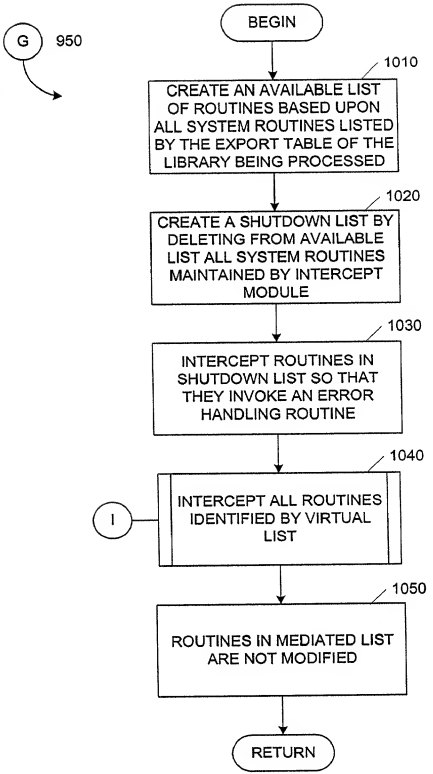
G
950
BEGIN
1010
CREATE AN AVAILABLE LIST OF ROUTINES BASED UPON ALL SYSTEM ROUTINES LISTED BY THE EXPORT TABLE OF THE LIBRARY BEING PROCESSED
1020
CREATE A SHUTDOWN LIST BY DELETING FROM AVAILABLE LIST ALL SYSTEM ROUTINES MAINTAINED BY INTERCEPT MODULE
1030
INTERCEPT ROUTINES IN SHUTDOWN LIST SO THAT THEY INVOKE AN ERROR HANDLING ROUTINE
1040
I
INTERCEPT ALL ROUTINES IDENTIFIED BY VIRTUAL LIST
1050
ROUTINES IN MEDIATED LIST ARE NOT MODIFIED
RETURN

FIG. 10

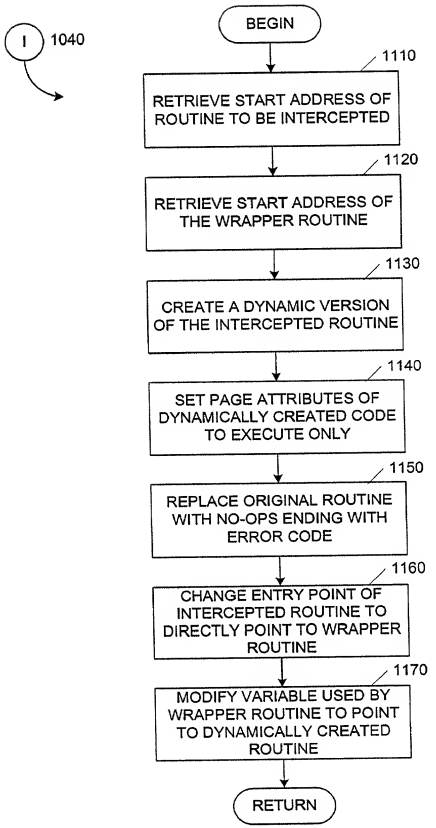
1040
BEGIN
1110
RETRIEVE START ADDRESS OF ROUTINE TO BE INTERCEPTED
1120
RETRIEVE START ADDRESS OF THE WRAPPER ROUTINE
1130
CREATE A DYNAMIC VERSION OF THE INTERCEPTED ROUTINE
1140
SET PAGE ATTRIBUTES OF DYNAMICALLY CREATED CODE TO EXECUTE ONLY
1150
REPLACE ORIGINAL ROUTINE WITH NO-OPS ENDING WITH ERROR CODE
1160
CHANGE ENTRY POINT OF INTERCEPTED ROUTINE TO DIRECTLY POINT TO WRAPPER ROUTINE
1170
MODIFY VARIABLE USED BY WRAPPER ROUTINE TO POINT TO DYNAMICALLY CREATED ROUTINE
RETURN

FIG. 11

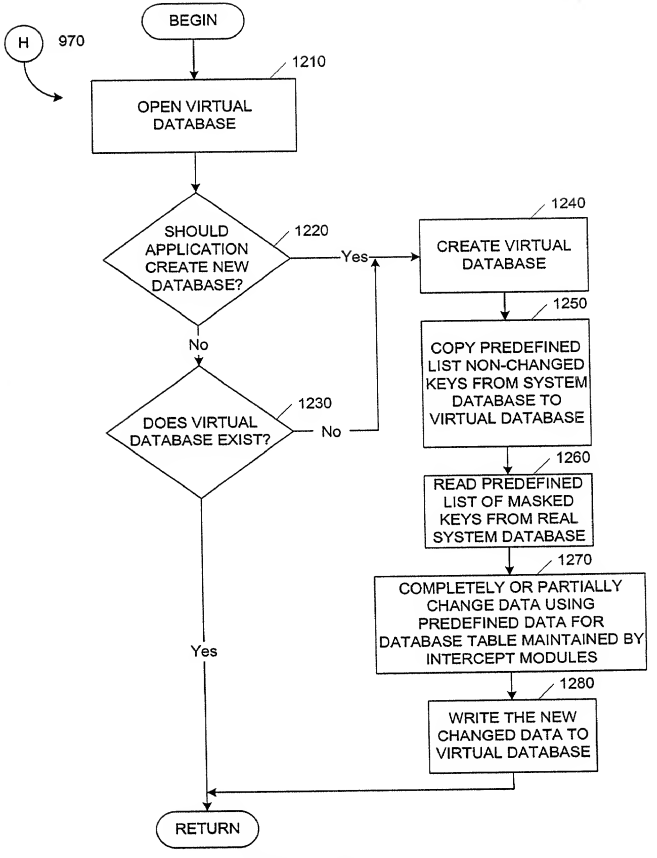
H
970
BEGIN
1210
OPEN VIRTUAL DATABASE
SHOULD APPLICATION CREATE NEW DATABASE?
1220
Yes
No
1240
CREATE VIRTUAL DATABASE
1250
COPY PREDEFINED LIST NON-CHANGED KEYS FROM SYSTEM DATABASE TO VIRTUAL DATABASE
DOES VIRTUAL DATABASE EXIST?
1230
No
Yes
1260
READ PREDEFINED LIST OF MASKED KEYS FROM REAL SYSTEM DATABASE
1270
COMPLETELY OR PARTIALLY CHANGE DATA USING PREDEFINED DATA FOR DATABASE TABLE MAINTAINED BY INTERCEPT MODULES
1280
WRITE THE NEW CHANGED DATA TO VIRTUAL DATABASE
RETURN

FIG. 12

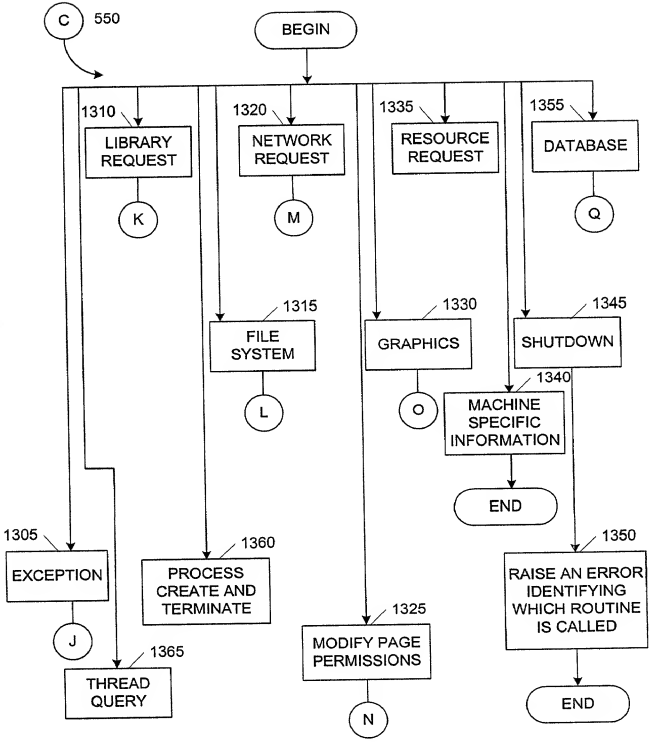
C
550
BEGIN
1310
LIBRARY REQUEST
1320
NETWORK REQUEST
1335
RESOURCE REQUEST
1355
DATABASE
K
M
Q
1315
FILE SYSTEM
1330
GRAPHICS
1345
SHUTDOWN
L
O
1340
MACHINE SPECIFIC INFORMATION
END
1305
EXCEPTION
1360
PROCESS CREATE AND TERMINATE
1350
RAISE AN ERROR IDENTIFYING WHICH ROUTINE IS CALLED
J
1325
MODIFY PAGE PERMISSIONS
1365
THREAD QUERY
N
END

FIG. 13

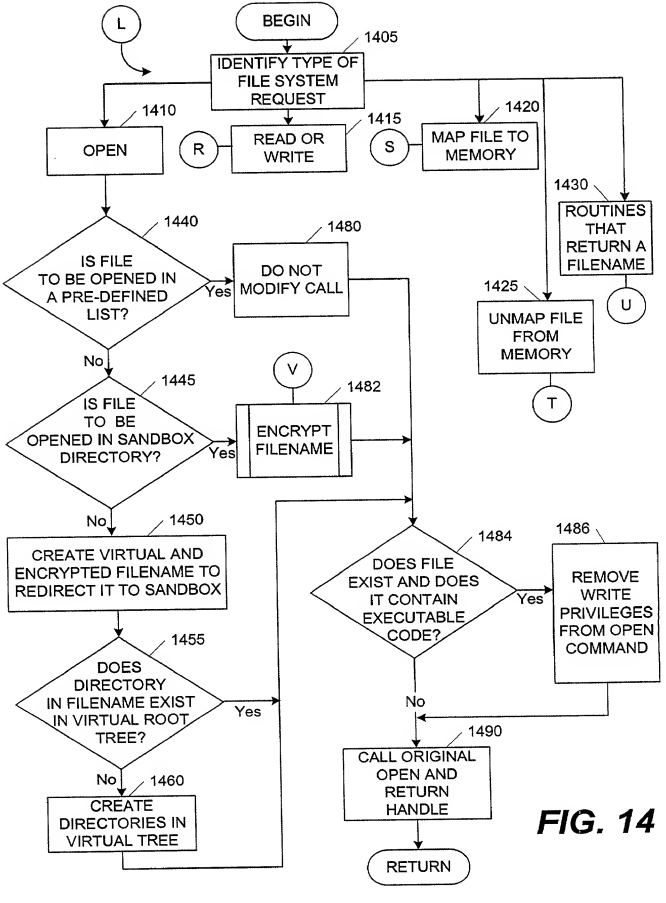
L
BEGIN
1405
IDENTIFY TYPE OF FILE SYSTEM REQUEST
1410
OPEN
R
1415
READ OR WRITE
S
1420
MAP FILE TO MEMORY
1430
ROUTINES THAT RETURN A FILENAME
U
1425
UNMAP FILE FROM MEMORY
T
1440
IS FILE TO BE OPENED IN A PRE-DEFINED LIST?
Yes
1480
DO NOT MODIFY CALL
No
V
1445
IS FILE TO BE OPENED IN SANDBOX DIRECTORY?
Yes
1482
ENCRYPT FILENAME
No
1450
CREATE VIRTUAL AND ENCRYPTED FILENAME TO REDIRECT IT TO SANDBOX
1455
DOES DIRECTORY IN FILENAME EXIST IN VIRTUAL ROOT TREE?
Yes
No
1460
CREATE DIRECTORIES IN VIRTUAL TREE
1484
DOES FILE EXIST AND DOES IT CONTAIN EXECUTABLE CODE?
Yes
1486
REMOVE WRITE PRIVILEGES FROM OPEN COMMAND
No
1490
CALL ORIGINAL OPEN AND RETURN HANDLE
RETURN

FIG. 14

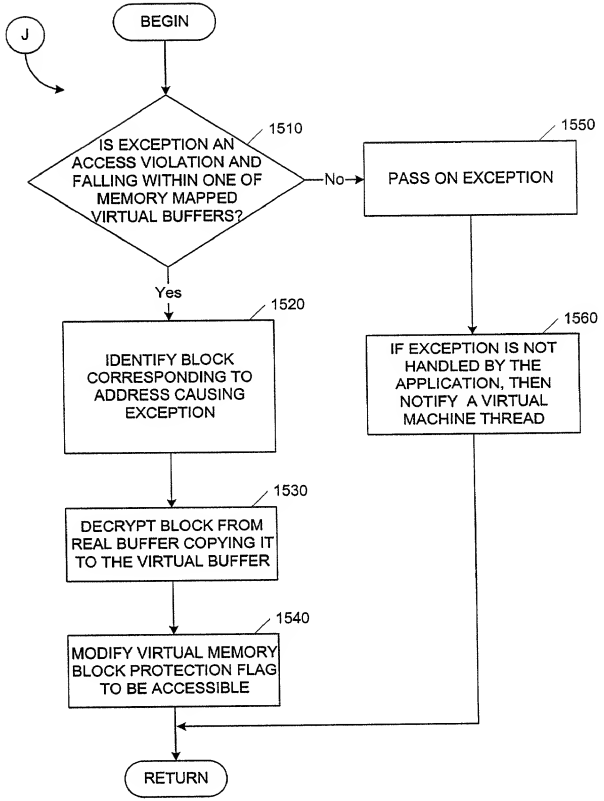
J
BEGIN
IS EXCEPTION AN ACCESS VIOLATION AND FALLING WITHIN ONE OF MEMORY MAPPED VIRTUAL BUFFERS?
1510
No
PASS ON EXCEPTION
1550
Yes
IDENTIFY BLOCK CORRESPONDING TO ADDRESS CAUSING EXCEPTION
1520
IF EXCEPTION IS NOT HANDLED BY THE APPLICATION, THEN NOTIFY A VIRTUAL MACHINE THREAD
1560
DECRYPT BLOCK FROM REAL BUFFER COPYING IT TO THE VIRTUAL BUFFER
1530
MODIFY VIRTUAL MEMORY BLOCK PROTECTION FLAG TO BE ACCESSIBLE
1540
RETURN

FIG. 15

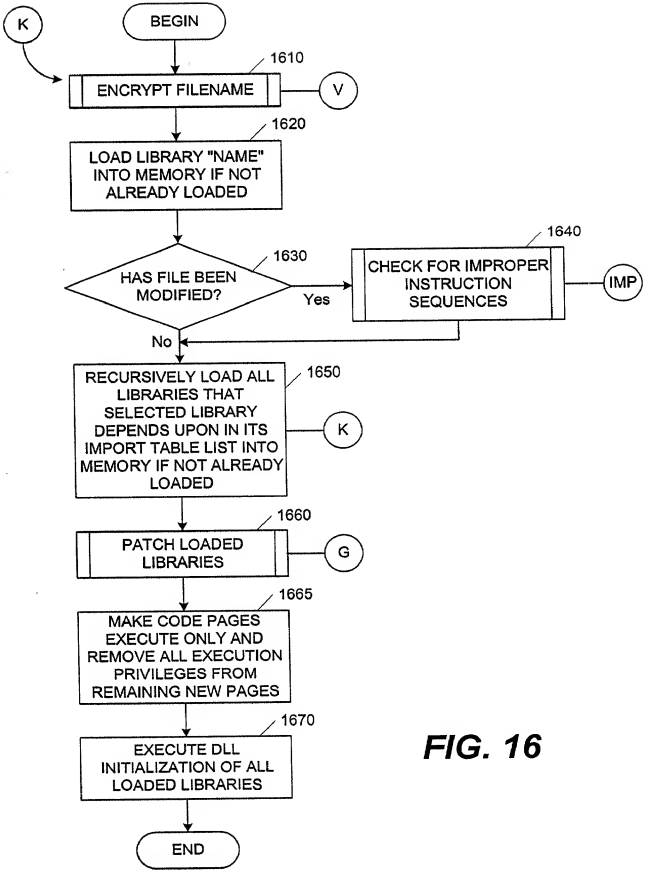
K
BEGIN
1610
ENCRYPT FILENAME
V
1620
LOAD LIBRARY "NAME" INTO MEMORY IF NOT ALREADY LOADED
1640
1630
HAS FILE BEEN MODIFIED?
Yes
CHECK FOR IMPROPER INSTRUCTION SEQUENCES
IMP
No
RECURSIVELY LOAD ALL LIBRARIES THAT SELECTED LIBRARY DEPENDS UPON IN ITS IMPORT TABLE LIST INTO MEMORY IF NOT ALREADY LOADED
1650
K
1660
PATCH LOADED LIBRARIES
G
1665
MAKE CODE PAGES EXECUTE ONLY AND REMOVE ALL EXECUTION PRIVILEGES FROM REMAINING NEW PAGES
1670
EXECUTE DLL INITIALIZATION OF ALL LOADED LIBRARIES
END

FIG. 16

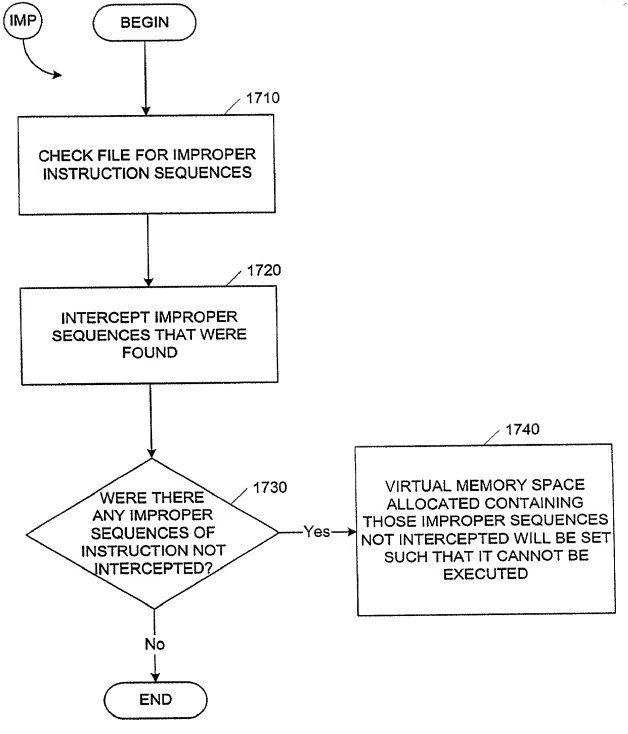
IMP
BEGIN
1710
CHECK FILE FOR IMPROPER INSTRUCTION SEQUENCES
1720
INTERCEPT IMPROPER SEQUENCES THAT WERE FOUND
1730
WERE THERE ANY IMPROPER SEQUENCES OF INSTRUCTION NOT INTERCEPTED?
Yes
1740
VIRTUAL MEMORY SPACE ALLOCATED CONTAINING THOSE IMPROPER SEQUENCES NOT INTERCEPTED WILL BE SET SUCH THAT IT CANNOT BE EXECUTED
No
END

FIG. 17

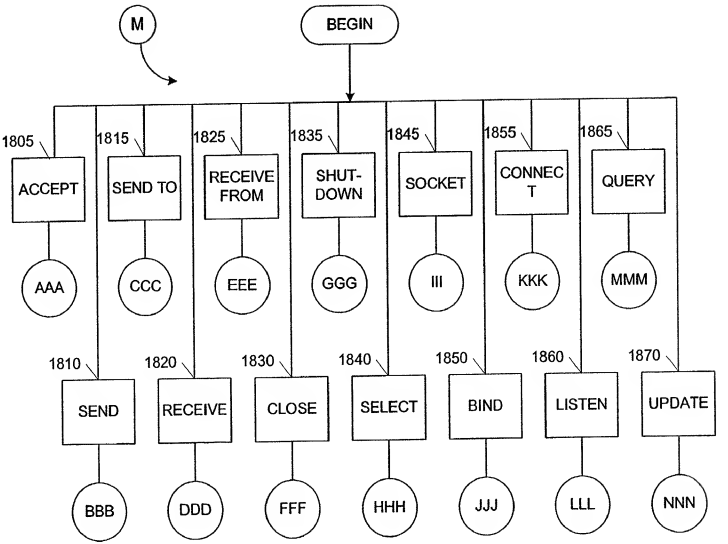
M
BEGIN
1805
ACCEPT
AAA
1815
SEND TO
CCC
1825
RECEIVE FROM
EEE
1835
SHUT-DOWN
GGG
1845
SOCKET
III
1855
CONNEC T
KKK
1865
QUERY
MMM
1810
SEND
BBB
1820
RECEIVE
DDD
1830
CLOSE
FFF
1840
SELECT
HHH
1850
BIND
JJJ
1860
LISTEN
LLL
1870
UPDATE
NNN

FIG. 18

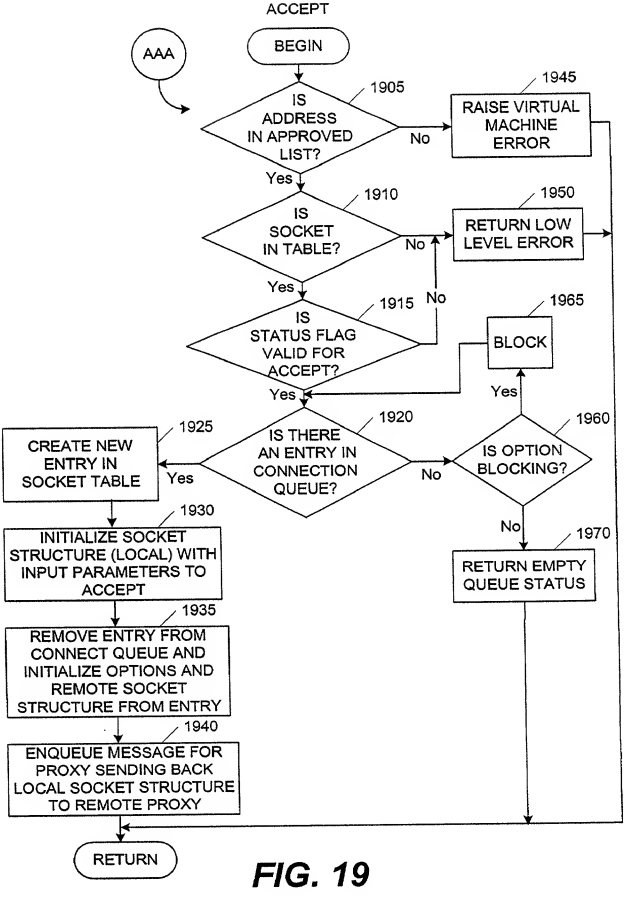
ACCEPT
AAA
BEGIN
IS ADDRESS IN APPROVED LIST?
1905
No
RAISE VIRTUAL MACHINE ERROR
1945
Yes
IS SOCKET IN TABLE?
1910
No
RETURN LOW LEVEL ERROR
1950
Yes
IS STATUS FLAG VALID FOR ACCEPT?
1915
No
BLOCK
1965
Yes
Yes
IS THERE AN ENTRY IN CONNECTION QUEUE?
1920
No
IS OPTION BLOCKING?
1960
Yes
CREATE NEW ENTRY IN SOCKET TABLE
1925
No
INITIALIZE SOCKET STRUCTURE (LOCAL) WITH INPUT PARAMETERS TO ACCEPT
1930
RETURN EMPTY QUEUE STATUS
1970
REMOVE ENTRY FROM CONNECT QUEUE AND INITIALIZE OPTIONS AND REMOTE SOCKET STRUCTURE FROM ENTRY
1935
ENQUEUE MESSAGE FOR PROXY SENDING BACK LOCAL SOCKET STRUCTURE TO REMOTE PROXY
1940
RETURN

FIG. 19

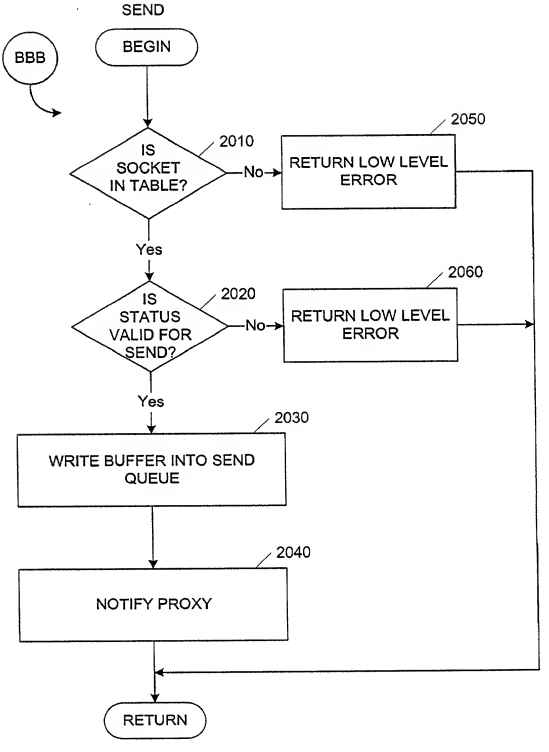
SEND
BBB
BEGIN
IS SOCKET IN TABLE?
2010
No
RETURN LOW LEVEL ERROR
2050
Yes
IS STATUS VALID FOR SEND?
2020
No
RETURN LOW LEVEL ERROR
2060
Yes
WRITE BUFFER INTO SEND QUEUE
2030
NOTIFY PROXY
2040
RETURN

FIG. 20

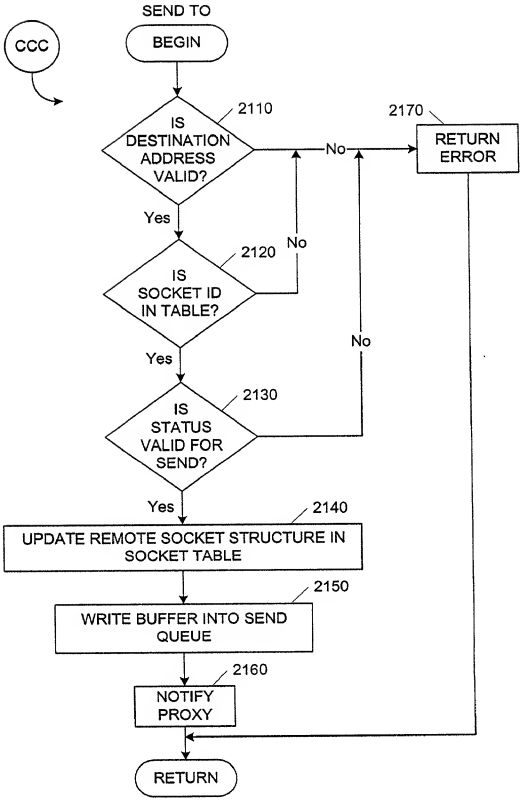
SEND TO
CCC
BEGIN
2110
IS DESTINATION ADDRESS VALID?
No
2170
RETURN ERROR
Yes
No
2120
IS SOCKET ID IN TABLE?
No
Yes
2130
IS STATUS VALID FOR SEND?
Yes
2140
UPDATE REMOTE SOCKET STRUCTURE IN SOCKET TABLE
2150
WRITE BUFFER INTO SEND QUEUE
2160
NOTIFY PROXY
RETURN

FIG. 21

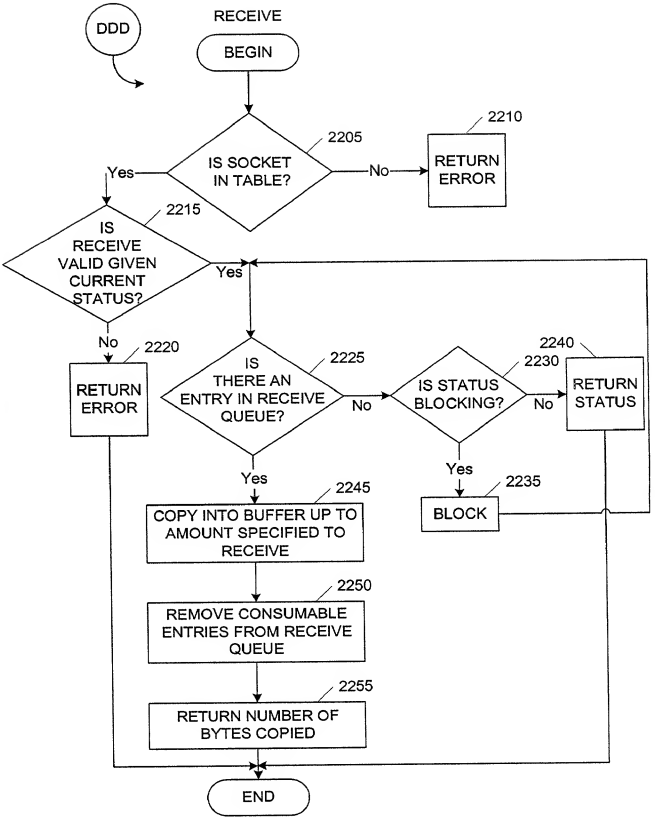
DDD
RECEIVE
BEGIN
IS SOCKET IN TABLE?
2205
Yes
No
RETURN ERROR
2210
IS RECEIVE VALID GIVEN CURRENT STATUS?
2215
Yes
No
RETURN ERROR
2220
IS THERE AN ENTRY IN RECEIVE QUEUE?
2225
No
IS STATUS BLOCKING?
2230
No
RETURN STATUS
2240
Yes
BLOCK
2235
Yes
COPY INTO BUFFER UP TO AMOUNT SPECIFIED TO RECEIVE
2245
REMOVE CONSUMABLE ENTRIES FROM RECEIVE QUEUE
2250
RETURN NUMBER OF BYTES COPIED
2255
END

FIG. 22

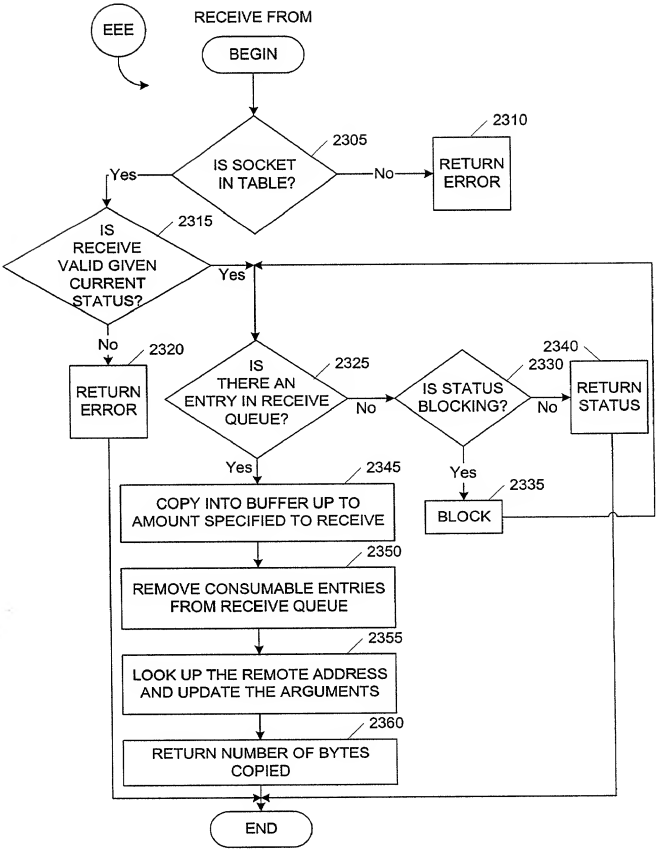
EEE
RECEIVE FROM
BEGIN
IS SOCKET IN TABLE?
2305
Yes
No
RETURN ERROR
2310
IS RECEIVE VALID GIVEN CURRENT STATUS?
2315
Yes
No
RETURN ERROR
2320
IS THERE AN ENTRY IN RECEIVE QUEUE?
2325
No
IS STATUS BLOCKING?
2330
No
RETURN STATUS
2340
Yes
BLOCK
2335
Yes
COPY INTO BUFFER UP TO AMOUNT SPECIFIED TO RECEIVE
2345
REMOVE CONSUMABLE ENTRIES FROM RECEIVE QUEUE
2350
LOOK UP THE REMOTE ADDRESS AND UPDATE THE ARGUMENTS
2355
RETURN NUMBER OF BYTES COPIED
2360
END

FIG. 23

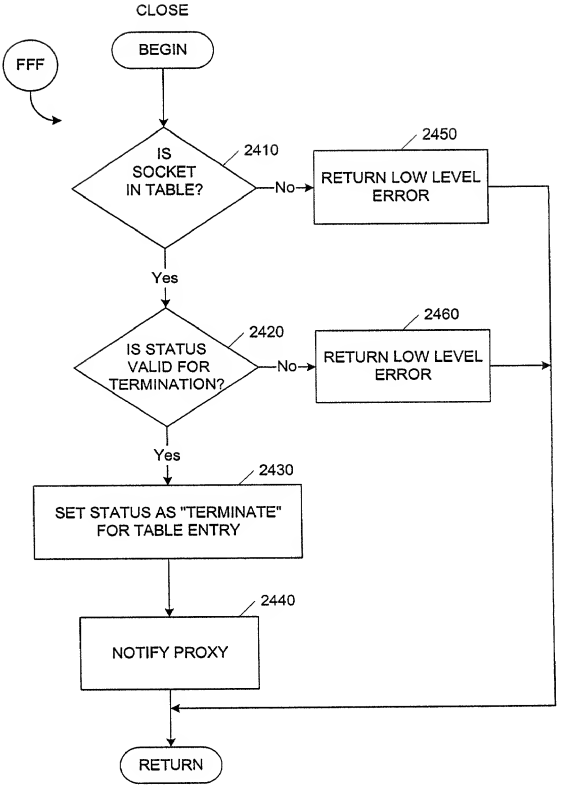
CLOSE
BEGIN
FFF
IS SOCKET IN TABLE?
2410
No
RETURN LOW LEVEL ERROR
2450
Yes
IS STATUS VALID FOR TERMINATION?
2420
No
RETURN LOW LEVEL ERROR
2460
Yes
SET STATUS AS "TERMINATE" FOR TABLE ENTRY
2430
NOTIFY PROXY
2440
RETURN

FIG. 24

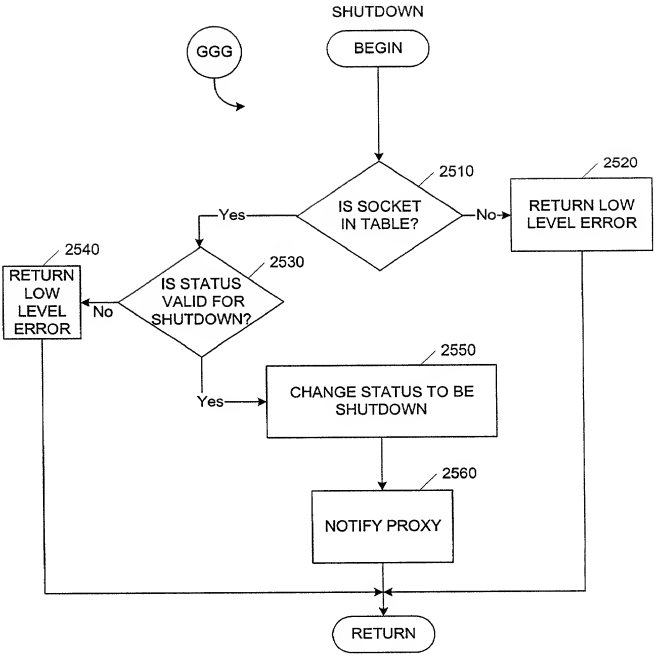
SHUTDOWN
GGG
BEGIN
2510
IS SOCKET IN TABLE?
Yes
No
2520
RETURN LOW LEVEL ERROR
2530
IS STATUS VALID FOR SHUTDOWN?
No
2540
RETURN LOW LEVEL ERROR
Yes
2550
CHANGE STATUS TO BE SHUTDOWN
2560
NOTIFY PROXY
RETURN

FIG. 25

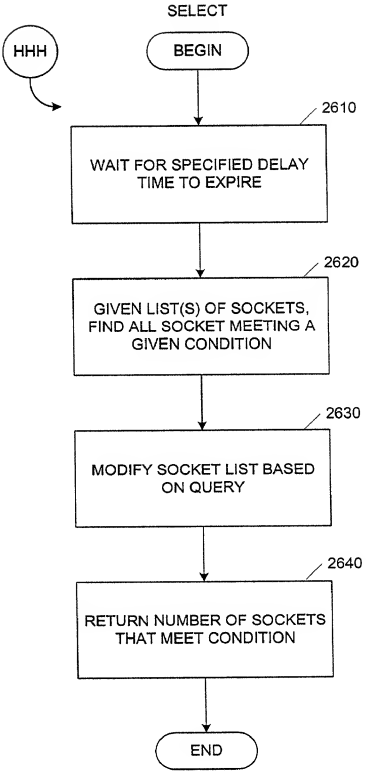
SELECT
HHH
BEGIN
2610
WAIT FOR SPECIFIED DELAY TIME TO EXPIRE
2620
GIVEN LIST(S) OF SOCKETS, FIND ALL SOCKET MEETING A GIVEN CONDITION
2630
MODIFY SOCKET LIST BASED ON QUERY
2640
RETURN NUMBER OF SOCKETS THAT MEET CONDITION
END

FIG. 26

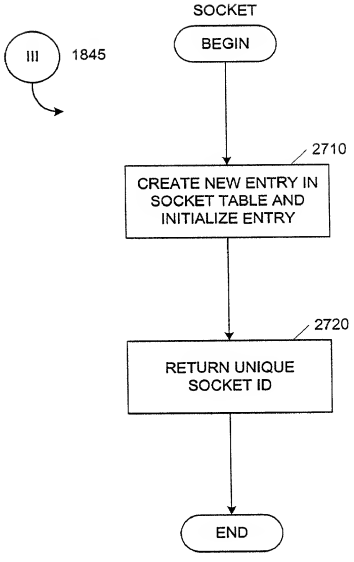
SOCKET
BEGIN
III
1845
2710
CREATE NEW ENTRY IN SOCKET TABLE AND INITIALIZE ENTRY
2720
RETURN UNIQUE SOCKET ID
END

FIG. 27

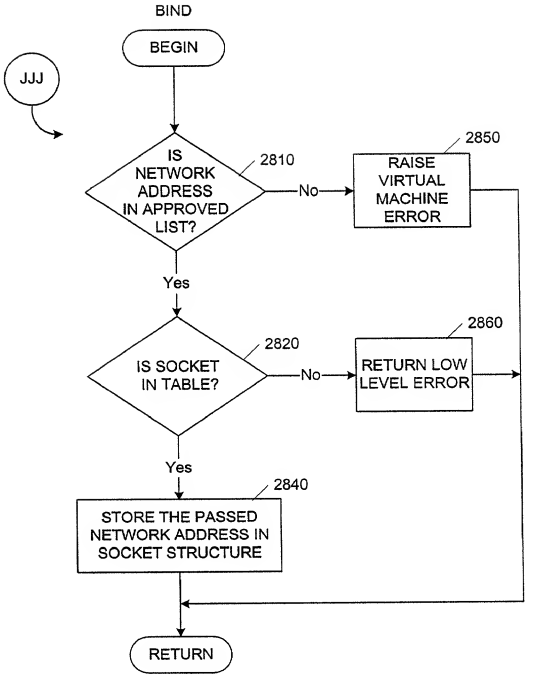
BIND
BEGIN
JJJ
IS NETWORK ADDRESS IN APPROVED LIST?
2810
No
RAISE VIRTUAL MACHINE ERROR
2850
Yes
IS SOCKET IN TABLE?
2820
No
RETURN LOW LEVEL ERROR
2860
Yes
STORE THE PASSED NETWORK ADDRESS IN SOCKET STRUCTURE
2840
RETURN

FIG. 28

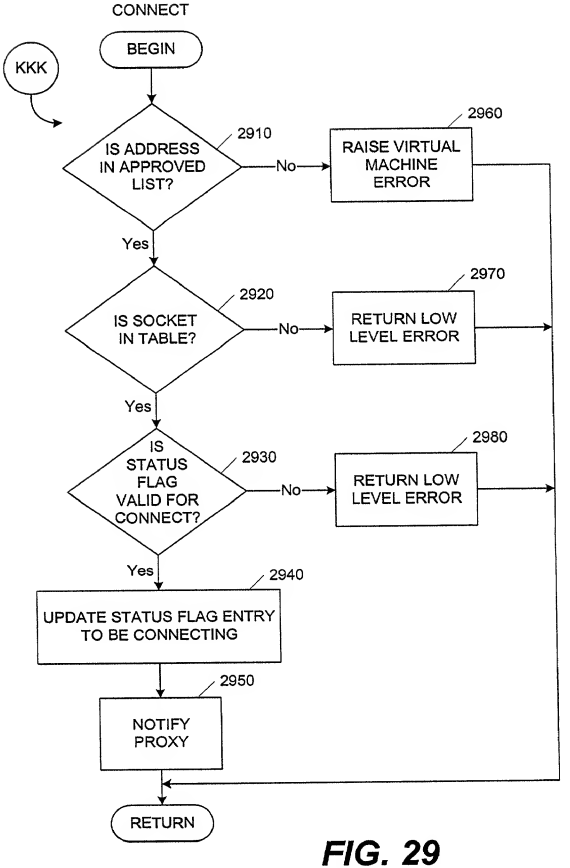
CONNECT
BEGIN
KKK
IS ADDRESS IN APPROVED LIST?
2910
No
RAISE VIRTUAL MACHINE ERROR
2960
Yes
IS SOCKET IN TABLE?
2920
No
RETURN LOW LEVEL ERROR
2970
Yes
IS STATUS FLAG VALID FOR CONNECT?
2930
No
RETURN LOW LEVEL ERROR
2980
Yes
UPDATE STATUS FLAG ENTRY TO BE CONNECTING
2940
NOTIFY PROXY
2950
RETURN

FIG. 29

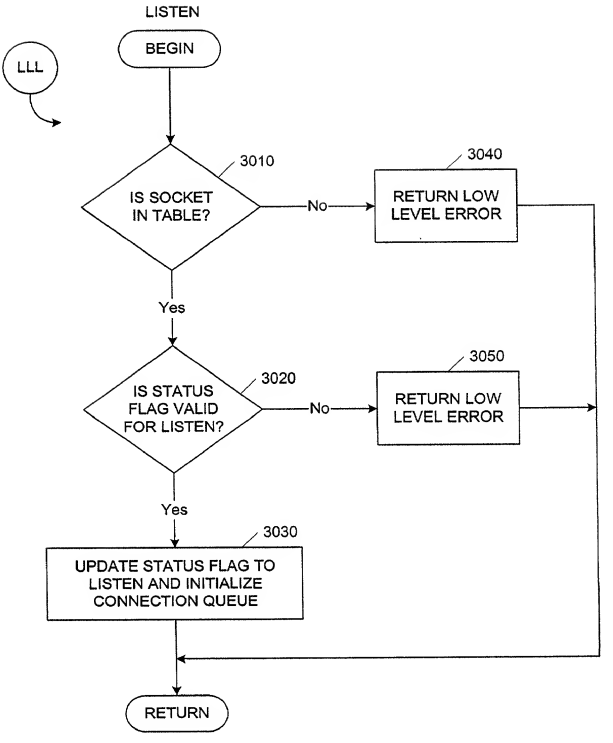
LISTEN
BEGIN
LLL
3010
IS SOCKET IN TABLE?
No
3040
RETURN LOW LEVEL ERROR
Yes
3020
IS STATUS FLAG VALID FOR LISTEN?
No
3050
RETURN LOW LEVEL ERROR
Yes
3030
UPDATE STATUS FLAG TO LISTEN AND INITIALIZE CONNECTION QUEUE
RETURN

FIG. 30

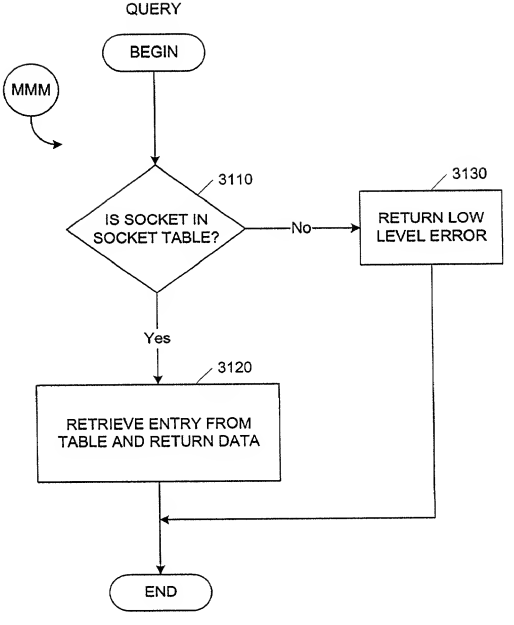
QUERY
BEGIN
MMM
3110
IS SOCKET IN SOCKET TABLE?
No
3130
RETURN LOW LEVEL ERROR
Yes
3120
RETRIEVE ENTRY FROM TABLE AND RETURN DATA
END

FIG. 31

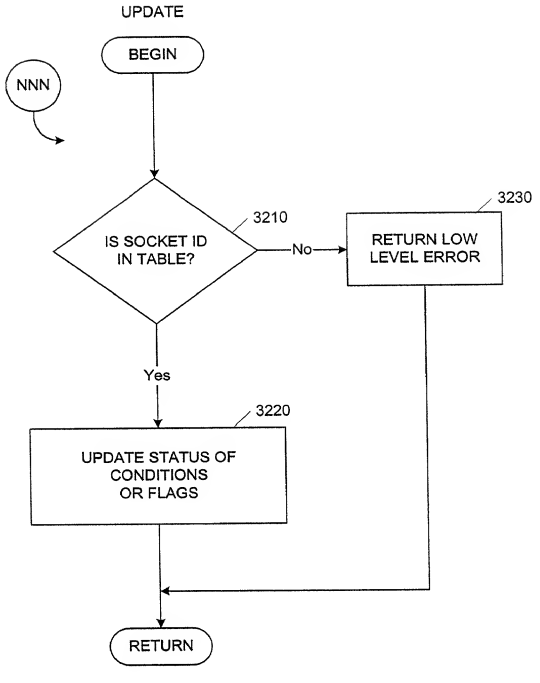
UPDATE
BEGIN
NNN
IS SOCKET ID IN TABLE?
3210
No
RETURN LOW LEVEL ERROR
3230
Yes
3220
UPDATE STATUS OF CONDITIONS OR FLAGS
RETURN

FIG. 32

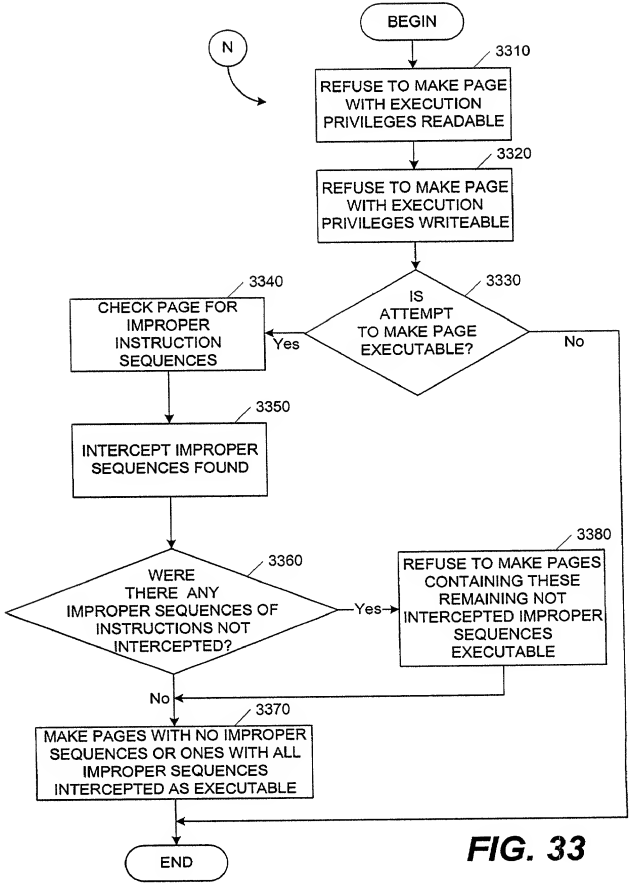
BEGIN
N
3310
REFUSE TO MAKE PAGE WITH EXECUTION PRIVILEGES READABLE
3320
REFUSE TO MAKE PAGE WITH EXECUTION PRIVILEGES WRITEABLE
3330
IS ATTEMPT TO MAKE PAGE EXECUTABLE?
Yes
No
3340
CHECK PAGE FOR IMPROPER INSTRUCTION SEQUENCES
3350
INTERCEPT IMPROPER SEQUENCES FOUND
3360
WERE THERE ANY IMPROPER SEQUENCES OF INSTRUCTIONS NOT INTERCEPTED?
Yes
3380
REFUSE TO MAKE PAGES CONTAINING THESE REMAINING NOT INTERCEPTED IMPROPER SEQUENCES EXECUTABLE
No
3370
MAKE PAGES WITH NO IMPROPER SEQUENCES OR ONES WITH ALL IMPROPER SEQUENCES INTERCEPTED AS EXECUTABLE
END

FIG. 33

TOSOSO' 80T-Z8Z60

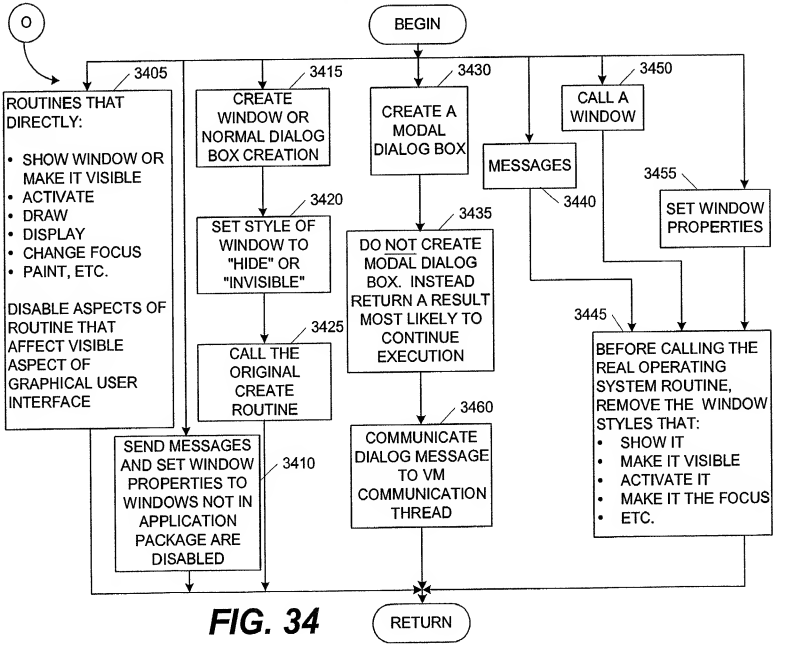

FIG. 34

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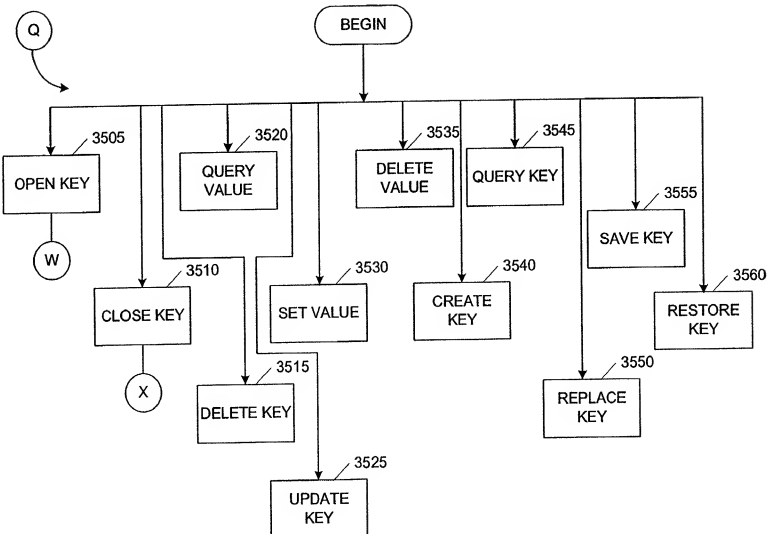

FIG. 35

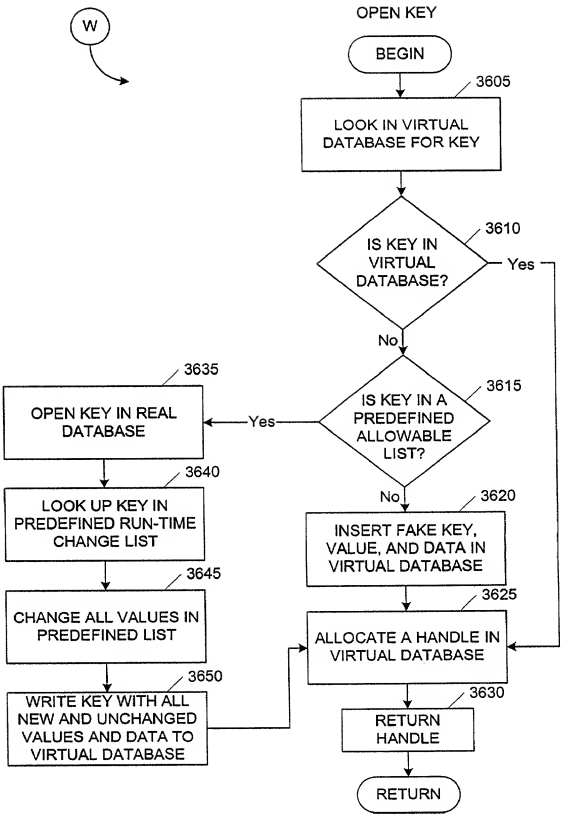
W
OPEN KEY
BEGIN
3605
LOOK IN VIRTUAL DATABASE FOR KEY
3610
IS KEY IN VIRTUAL DATABASE?
Yes
No
3615
IS KEY IN A PREDEFINED ALLOWABLE LIST?
Yes
3635
OPEN KEY IN REAL DATABASE
No
3620
INSERT FAKE KEY, VALUE, AND DATA IN VIRTUAL DATABASE
3640
LOOK UP KEY IN PREDEFINED RUN-TIME CHANGE LIST
3645
CHANGE ALL VALUES IN PREDEFINED LIST
3650
WRITE KEY WITH ALL NEW AND UNCHANGED VALUES AND DATA TO VIRTUAL DATABASE
3625
ALLOCATE A HANDLE IN VIRTUAL DATABASE
3630
RETURN HANDLE
RETURN

FIG. 36

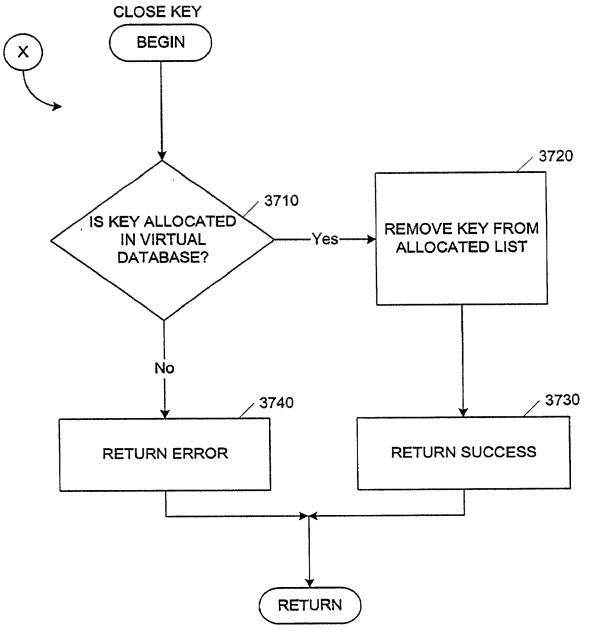
CLOSE KEY
BEGIN
X
IS KEY ALLOCATED IN VIRTUAL DATABASE?
3710
Yes
No
REMOVE KEY FROM ALLOCATED LIST
3720
RETURN ERROR
3740
RETURN SUCCESS
3730
RETURN

FIG. 37

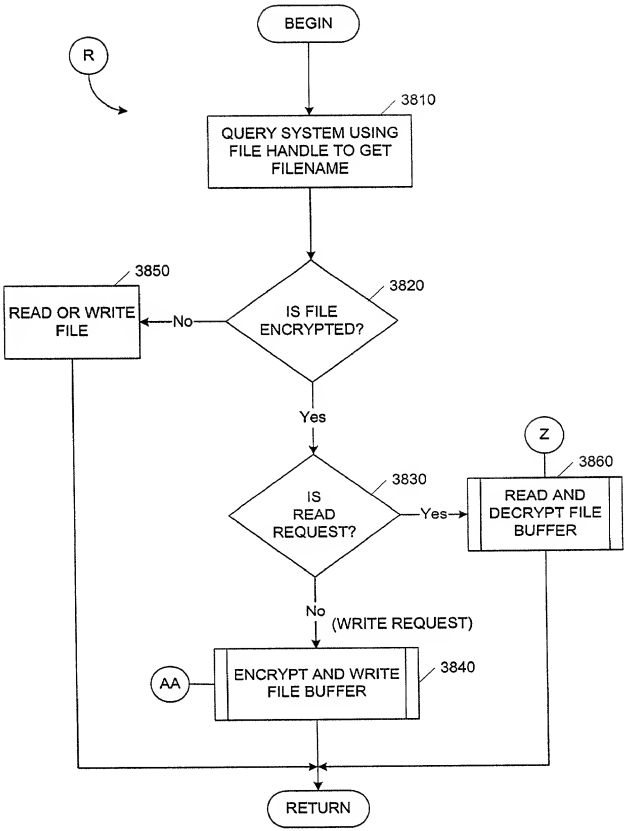
BEGIN
R
3810
QUERY SYSTEM USING FILE HANDLE TO GET FILENAME
3850
READ OR WRITE FILE
No
3820
IS FILE ENCRYPTED?
Yes
Z
3860
READ AND DECRYPT FILE BUFFER
3830
IS READ REQUEST?
Yes
No
(WRITE REQUEST)
AA
ENCRYPT AND WRITE FILE BUFFER
3840
RETURN

FIG. 38

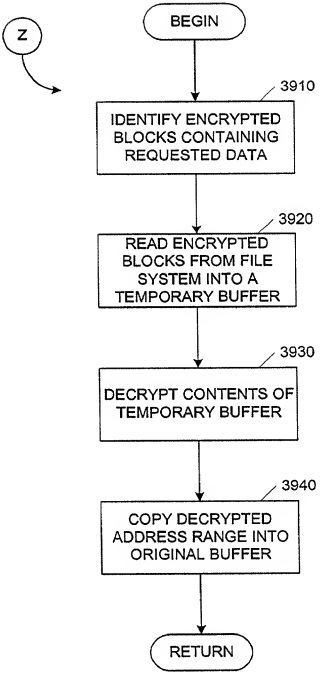
Z
BEGIN
3910
IDENTIFY ENCRYPTED BLOCKS CONTAINING REQUESTED DATA
3920
READ ENCRYPTED BLOCKS FROM FILE SYSTEM INTO A TEMPORARY BUFFER
3930
DECRYPT CONTENTS OF TEMPORARY BUFFER
3940
COPY DECRYPTED ADDRESS RANGE INTO ORIGINAL BUFFER
RETURN

FIG. 39

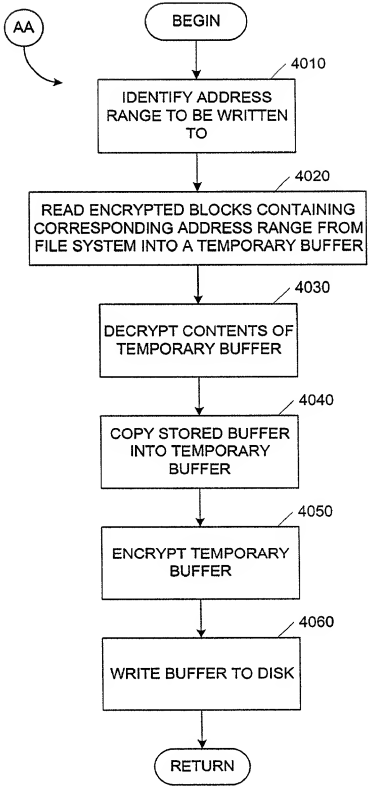
AA
BEGIN
4010
IDENTIFY ADDRESS RANGE TO BE WRITTEN TO
4020
READ ENCRYPTED BLOCKS CONTAINING CORRESPONDING ADDRESS RANGE FROM FILE SYSTEM INTO A TEMPORARY BUFFER
4030
DECRYPT CONTENTS OF TEMPORARY BUFFER
4040
COPY STORED BUFFER INTO TEMPORARY BUFFER
4050
ENCRYPT TEMPORARY BUFFER
4060
WRITE BUFFER TO DISK
RETURN

FIG. 40

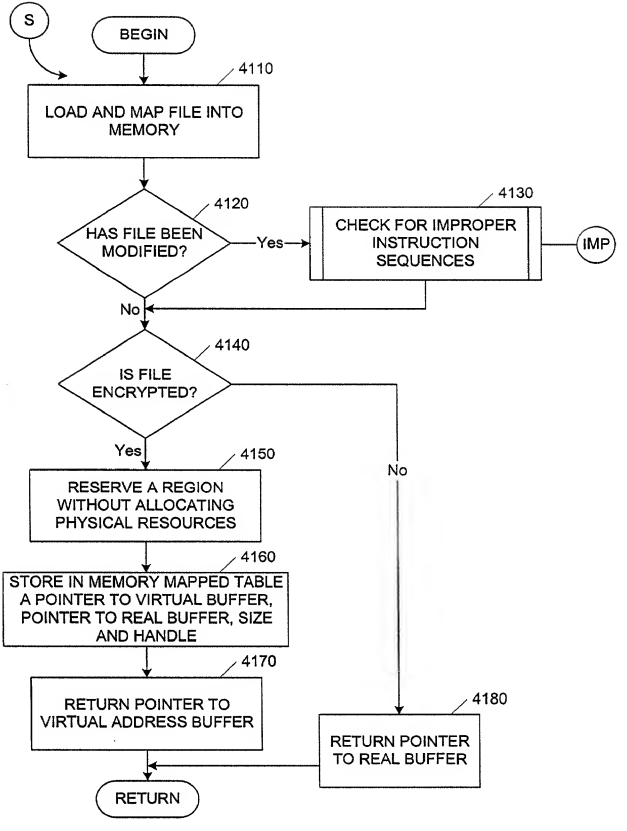
S
BEGIN
4110
LOAD AND MAP FILE INTO MEMORY
4120
HAS FILE BEEN MODIFIED?
Yes
4130
CHECK FOR IMPROPER INSTRUCTION SEQUENCES
IMP
No
4140
IS FILE ENCRYPTED?
Yes
No
4150
RESERVE A REGION WITHOUT ALLOCATING PHYSICAL RESOURCES
4160
STORE IN MEMORY MAPPED TABLE A POINTER TO VIRTUAL BUFFER, POINTER TO REAL BUFFER, SIZE AND HANDLE
4170
RETURN POINTER TO VIRTUAL ADDRESS BUFFER
4180
RETURN POINTER TO REAL BUFFER
RETURN

FIG. 41

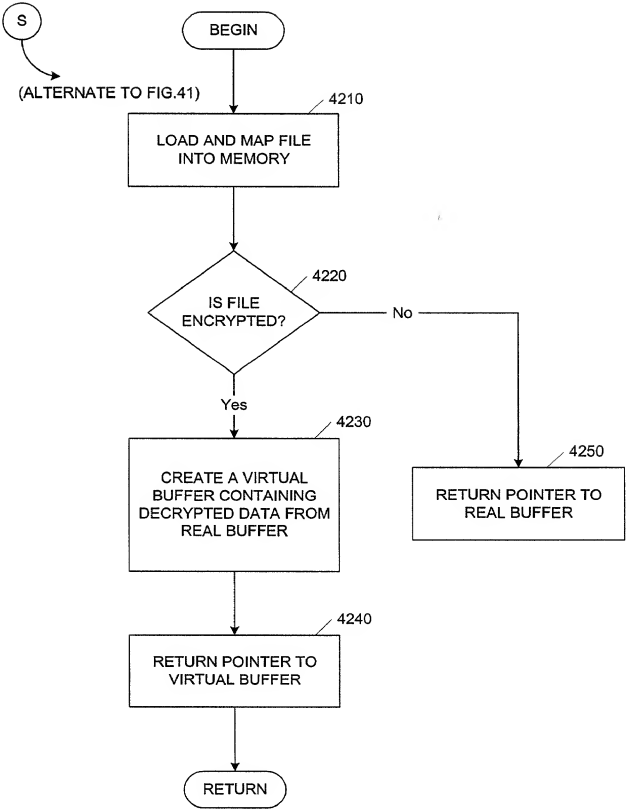
S
(ALTERNATE TO FIG.41)
BEGIN
4210
LOAD AND MAP FILE INTO MEMORY
4220
IS FILE ENCRYPTED?
No
Yes
4230
CREATE A VIRTUAL BUFFER CONTAINING DECRYPTED DATA FROM REAL BUFFER
4250
RETURN POINTER TO REAL BUFFER
4240
RETURN POINTER TO VIRTUAL BUFFER
RETURN

FIG. 42

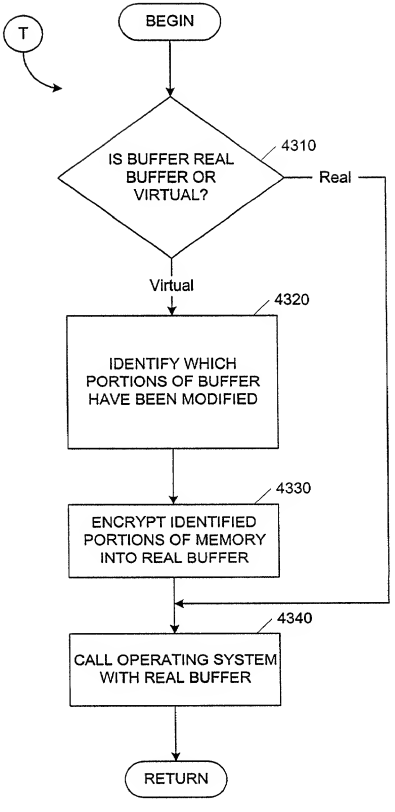
T
BEGIN
IS BUFFER REAL BUFFER OR VIRTUAL?
4310
Real
Virtual
4320
IDENTIFY WHICH PORTIONS OF BUFFER HAVE BEEN MODIFIED
4330
ENCRYPT IDENTIFIED PORTIONS OF MEMORY INTO REAL BUFFER
4340
CALL OPERATING SYSTEM WITH REAL BUFFER
RETURN

FIG. 43

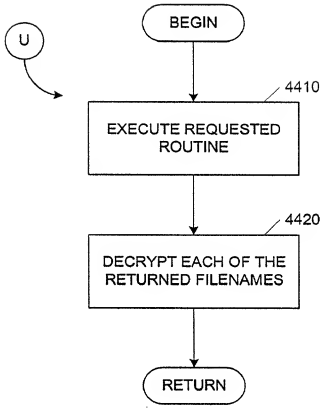
U
BEGIN
4410
EXECUTE REQUESTED ROUTINE
4420
DECRYPT EACH OF THE RETURNED FILENAMES
RETURN

FIG. 44

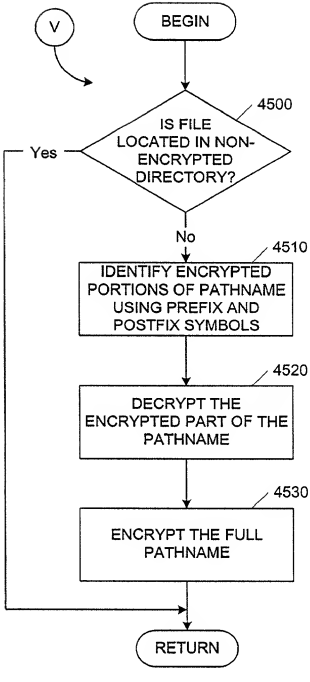
V
BEGIN
4500
IS FILE LOCATED IN NON-ENCRYPTED DIRECTORY?
Yes
No
4510
IDENTIFY ENCRYPTED PORTIONS OF PATHNAME USING PREFIX AND POSTFIX SYMBOLS
4520
DECRYPT THE ENCRYPTED PART OF THE PATHNAME
4530
ENCRYPT THE FULL PATHNAME
RETURN

FIG. 45

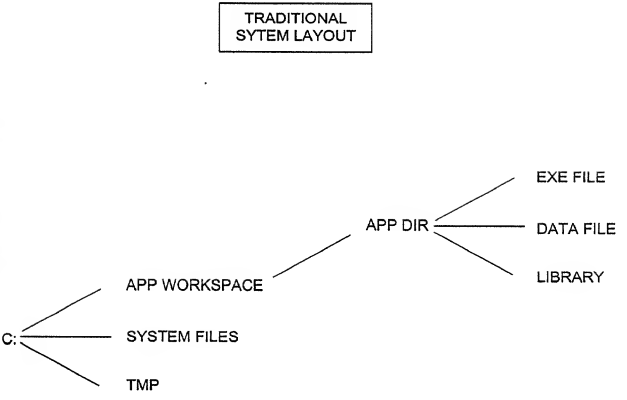
TRADITIONAL
SYTEM LAYOUT
C:
APP WORKSPACE
SYSTEM FILES
TMP
APP DIR
EXE FILE
DATA FILE
LIBRARY

FIG. 46

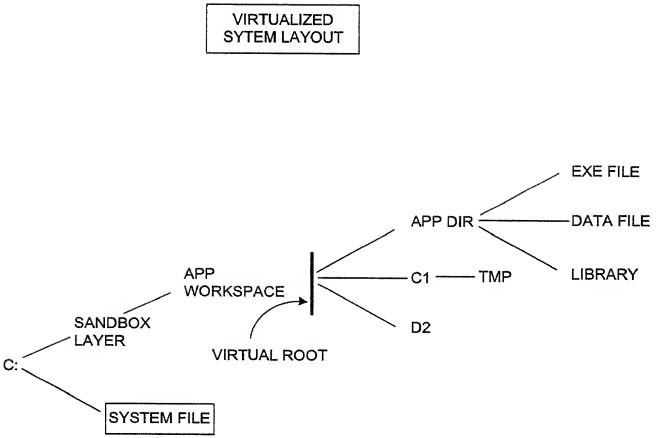
VIRTUALIZED
SYTEM LAYOUT
EXE FILE
APP DIR
DATA FILE
APP
WORKSPACE
C1
TMP
LIBRARY
SANDBOX
LAYER
D2
C:
VIRTUAL ROOT
SYSTEM FILE

FIG. 47

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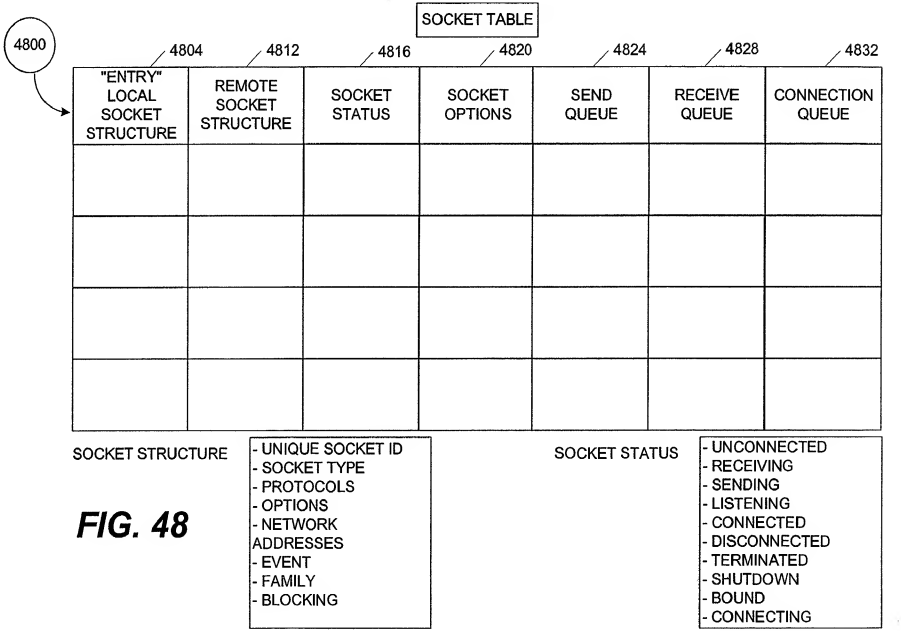

FIG. 48

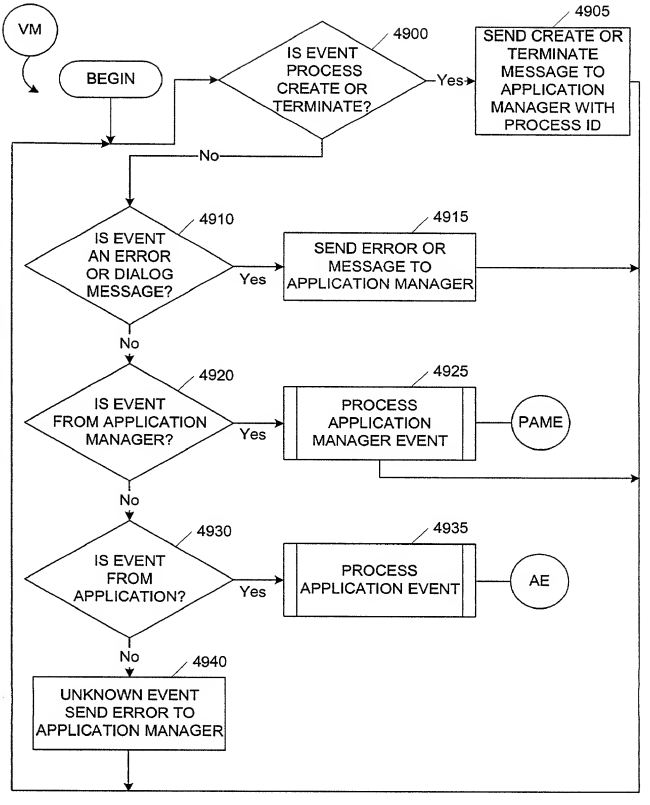
VM
BEGIN
IS EVENT PROCESS CREATE OR TERMINATE?
4900
Yes
SEND CREATE OR TERMINATE MESSAGE TO APPLICATION MANAGER WITH PROCESS ID
4905
No
IS EVENT AN ERROR OR DIALOG MESSAGE?
4910
Yes
SEND ERROR OR MESSAGE TO APPLICATION MANAGER
4915
No
IS EVENT FROM APPLICATION MANAGER?
4920
Yes
PROCESS APPLICATION MANAGER EVENT
4925
PAME
No
IS EVENT FROM APPLICATION?
4930
Yes
PROCESS APPLICATION EVENT
4935
AE
No
UNKNOWN EVENT SEND ERROR TO APPLICATION MANAGER
4940

FIG. 49

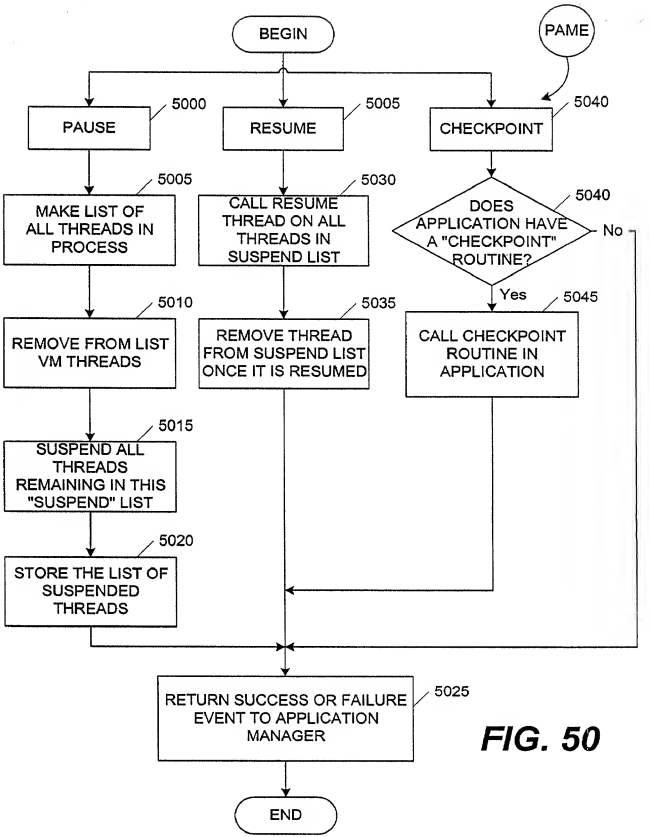
BEGIN
PAME
PAUSE
5000
RESUME
5005
CHECKPOINT
5040
MAKE LIST OF ALL THREADS IN PROCESS
5005
CALL RESUME THREAD ON ALL THREADS IN SUSPEND LIST
5030
DOES APPLICATION HAVE A "CHECKPOINT" ROUTINE?
5040
No
Yes
REMOVE FROM LIST VM THREADS
5010
REMOVE THREAD FROM SUSPEND LIST ONCE IT IS RESUMED
5035
CALL CHECKPOINT ROUTINE IN APPLICATION
5045
SUSPEND ALL THREADS REMAINING IN THIS "SUSPEND" LIST
5015
STORE THE LIST OF SUSPENDED THREADS
5020
RETURN SUCCESS OR FAILURE EVENT TO APPLICATION MANAGER
5025
END

FIG. 50

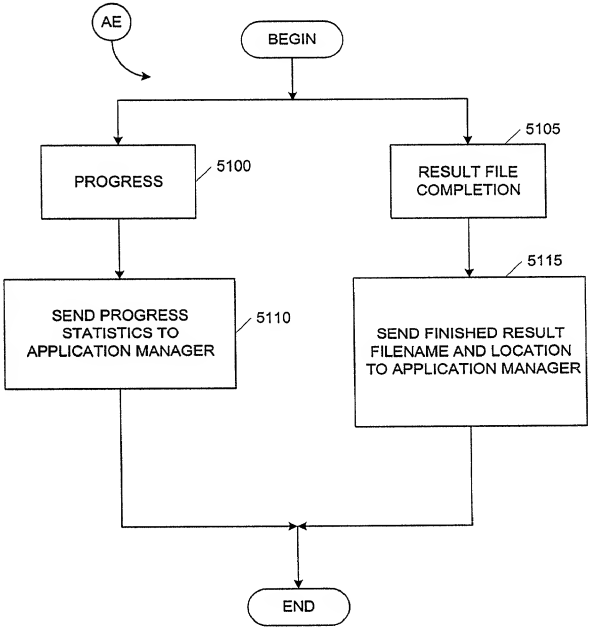
AE
BEGIN
PROGRESS
5100
RESULT FILE COMPLETION
5105
SEND PROGRESS STATISTICS TO APPLICATION MANAGER
5110
SEND FINISHED RESULT FILENAME AND LOCATION TO APPLICATION MANAGER
5115
END

FIG. 51